Summary Report

Statistical Trajectory Analysis for Mandatory Federal Class I areas Closest to Iowa

Purpose

The purpose of this document is to describe the results, methodology and data used to calculate probability statistics based on a combination of ambient air quality monitoring data and back trajectory modeling. In general, the probability plots presented in this paper provide a spatial snapshot of how frequently an air parcel that was measured at an IMPROVE monitor in a specific Class I area traveled through a given upwind area.

It should be noted that due to the complexity of physical and chemical processes controlling the transport, diffusion and transformation of air pollutants, these analyses are not adequate to determine specific culpability of an area to a given air quality issue. In general, these analyses provide assistance in identifying and prioritizing downwind areas that are more likely impacted by emissions from the State of Iowa.

Methodology

The statistical basis for these calculations is the white paper "Ensemble Trajectory Analysis" dated June 2001, prepared by Donna Kenski of the Lake Michigan Air Directors Consortium. Within that paper the definition of incremental probability is provided as:

Incremental Probability $= m_{ij}/M - n_{ij}/N$

where:

m_{ij}/M is the worst day probability for a given grid cell, and

n_{ij}/N is the everyday probability for a given grid cell.

m_{ij} is the number of worst day trajectory endpoints in a given (i,j) grid cell,

n_{ij} is the total number of trajectory endpoints in a given (i,j) grid cell for all days,

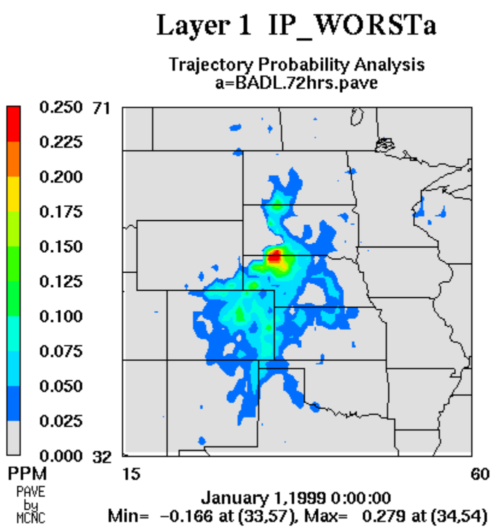
M is the total number of trajectory endpoints in all grid cells for worst days,

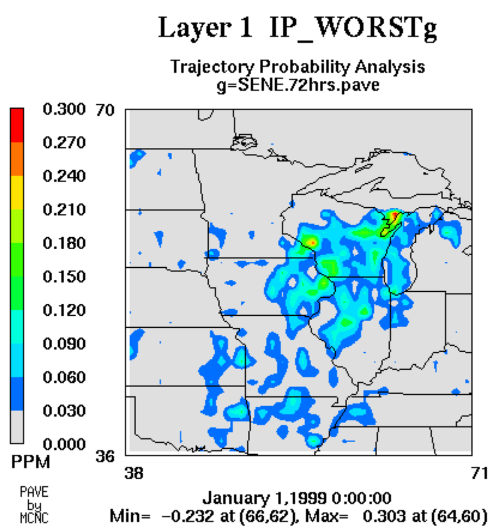
N is the total number of trajectory endpoints in all grid cells for all days.

The incremental probability ($m_{ij}/M - n_{ij}/N$) can then be explained as the worst day probability minus the everyday probability, or the "excess" probability that remains when the everyday probability is removed from the worst day probability. From the Kenski (2001) paper: "The resulting surface identifies where the probability of poor air quality is higher than the every day probability." In other words, the higher the value of a specific grid cell, the more likely that air passing through that grid cell will be associated with higher concentrations (or in this case visibility impairment) will be measured at the receptor (monitor).

It should be noted that the number value of the probability fields are dependent on many factors including grid cell resolution, number of observations and back trajectories, etc, and therefore are difficult if not impossible to assign concrete meaning to. More important are the “looks” of the surface developed and the relative differences or gradients between one area and another.

As an example, the following plots illustrate the incremental probability surface for the worst days at Badlands Wilderness, SD, and Seney Wilderness, MI.





As expected, the geographic areas identified as more frequently being upwind on the 20% worst visibility days at each site are different. It should also be noted that the plot for the Badlands appears more consistent while the plot for Seney is more diffuse. This is likely the result of multiple factors including differences in the length of the data record available at each site.

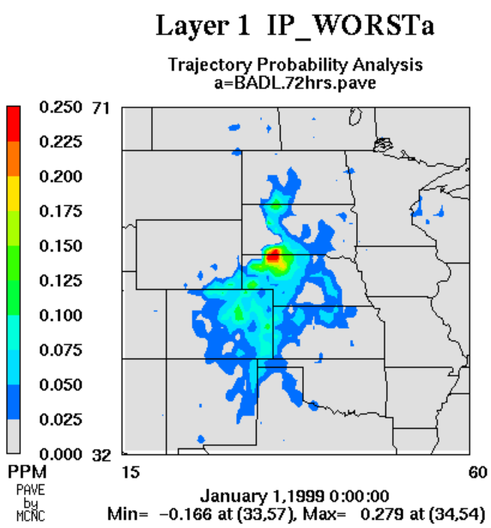
For this analysis two data sets were used. The first data set is the derived light extinction data available at the Visibility and Information Exchange Web System (VIEWS: http://vista.cira.colostate.edu/views/). These values are calculated from the IMPROVE ambient monitoring network according to federal guidance methods for reconstructing visibility from measured aerosol components. The second data set is the draft ATAD back trajectory modeling conducted by the National Park Service. The National Park Service has conducted this modeling for all 156 Mandatory Federal Class I areas for the time period of 1988 to 2002. The back trajectories are available every six hours and were run 120 hours back in time. The back trajectory modeling yields a set of 40 endpoints for each run (one every 3 hours), tracing the location of am air parcel back in time. In this analysis 72 hours of the 120-hour back trajectories were used.
This analysis was conducted in a two step process. First the derived visibility values were sorted into the twenty percent best, twenty percent worst, and twenty percent

highest for each of visibility impairing species (sulfates, nitrates, elemental carbon, etc.). Back trajectories were likewise sorted by the dates of the observations for the various categories. Next, the trajectory endpoints were gridded to a one-half degree by one-half grid. The total numbers of endpoints in each grid cell were summed for all observations and each subset of the observations such as best days and worst days. From these counts of endpoints in each grid cell the calculation of the incremental probability was made.

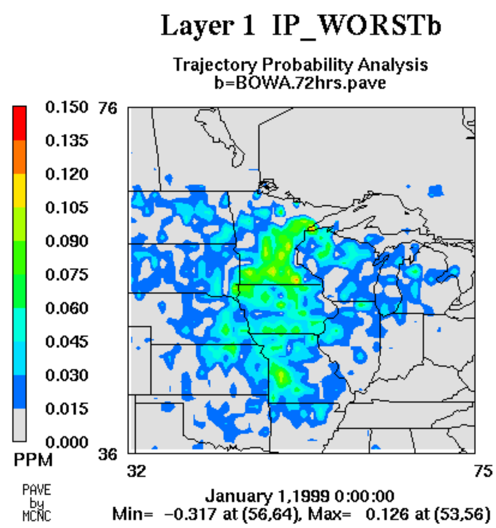
Results

The following plots provide a graphical illustration of the incremental probability for each of the Class I areas included in this analysis. Please note the date and PPM information shown on these plots is irrelevant and strictly an artifact of the plotting software.

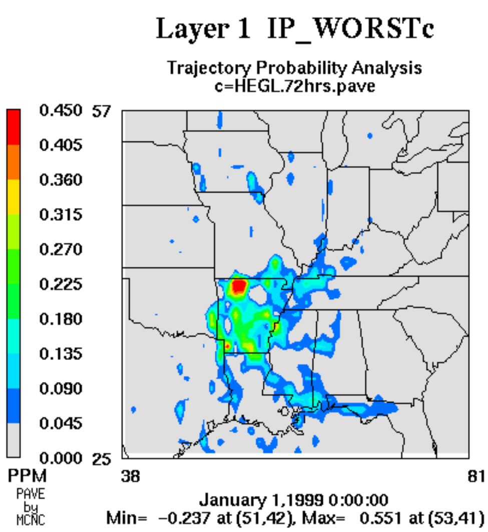
Badlands, SD



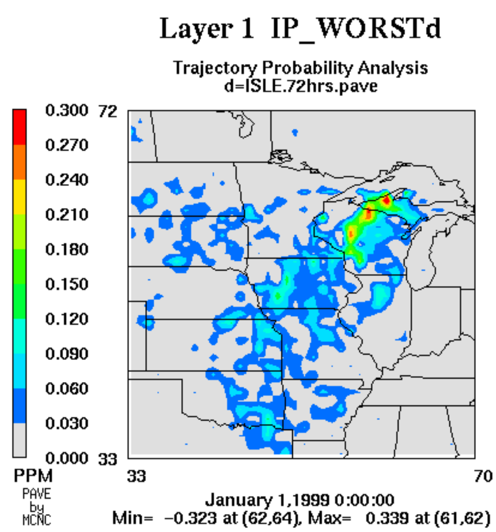
Bowdary Waters, MN



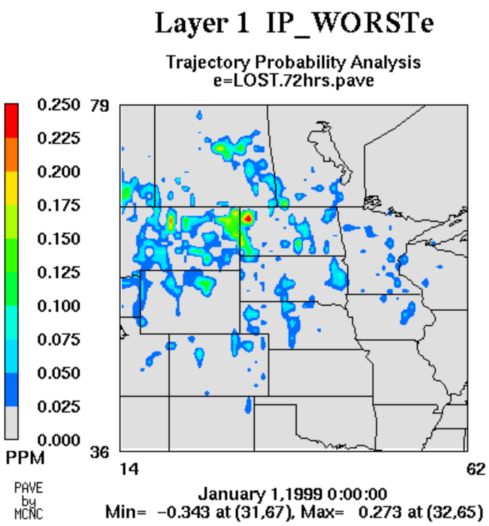
Hercules Glades, MO



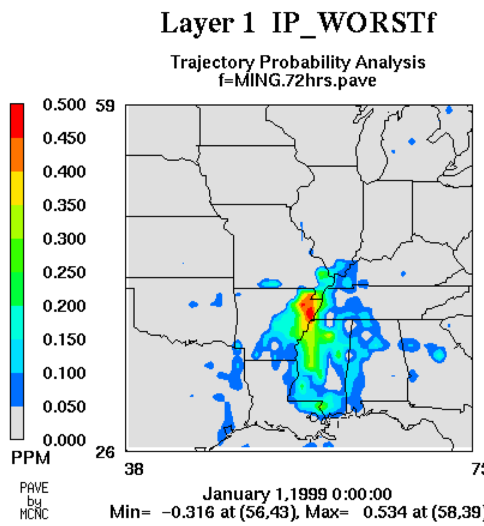
Isle Royale, MI



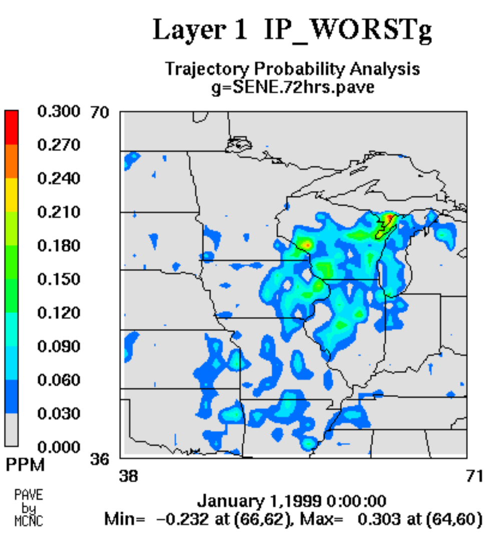
Lostwood, ND



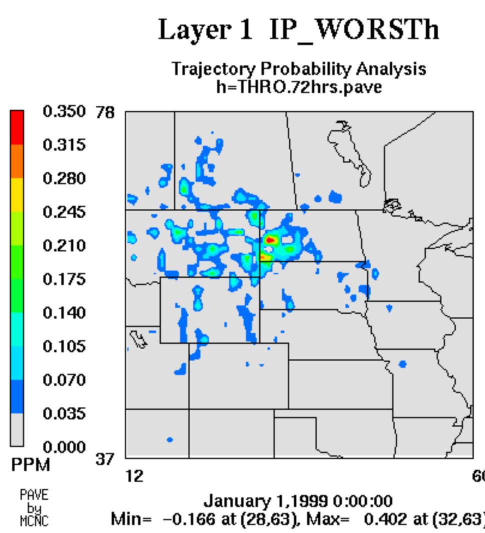
Mingo, MO



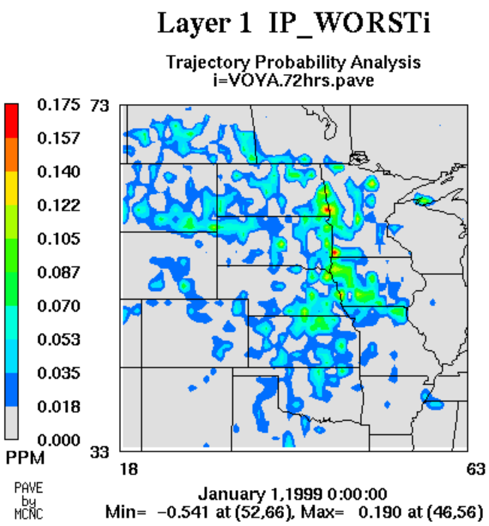
Seney, MI



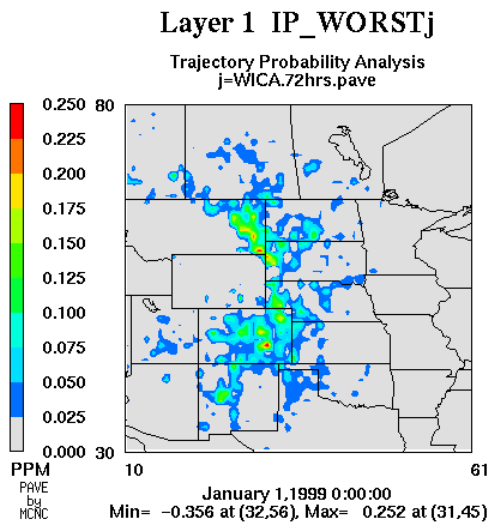
Theodore Roosevelt, ND



Voyagers, MN



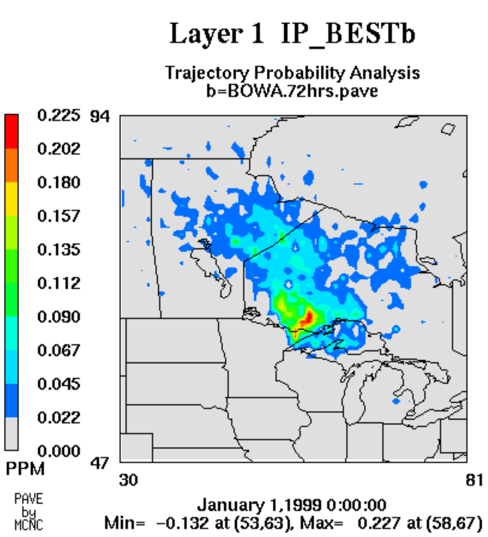
Wind Cave, SD



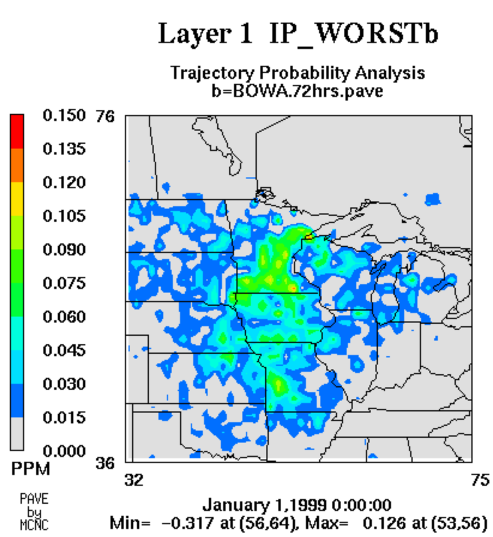
As can be seen from the above plots, incremental probability fields for sites to the west and south of the State of Iowa show virtually no increase in probability of poor visibility days associated with the geographic region of Iowa. Conversely, the incremental probability surfaces indicate that sites to the north and northeast of the State of Iowa have a higher probability of poor visibility days when the air parcel has passed through portions of the State. Both of these results are consistent with climatological wind patterns, especially during the summer months when the role of humidity in association with aerosol light extinction is typically amplified.

Additional analyses are presented for the Boundary Waters, MN, site. These plots separate out the incremental probability for the twenty-percent best and worst days, and the twenty-percent highest species specific days.

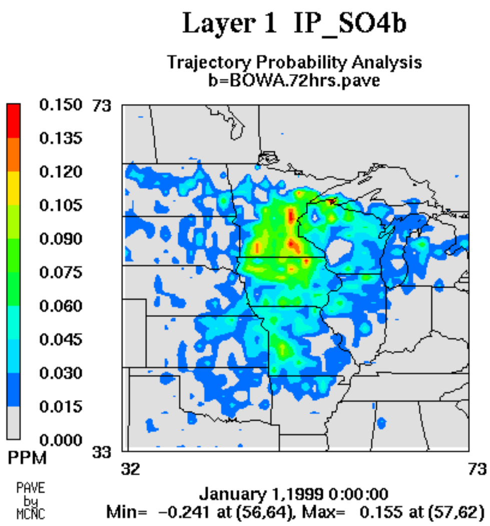
20% Best Days



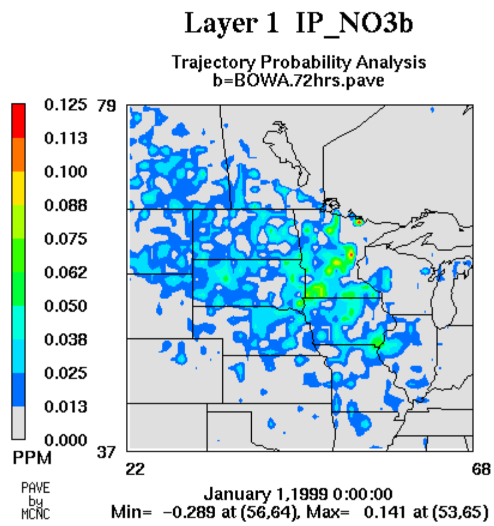
20% Worst Days



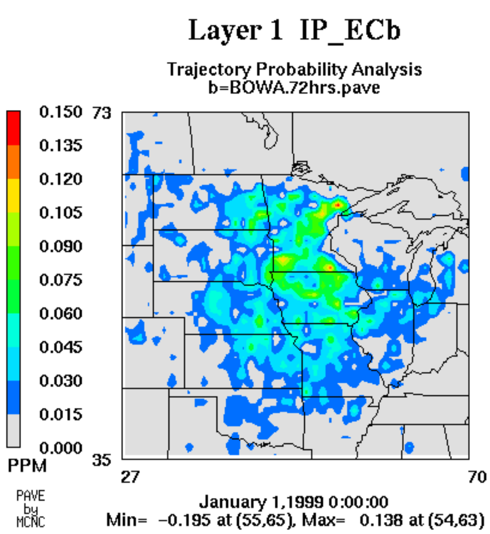
20% Highest Sulfate Days



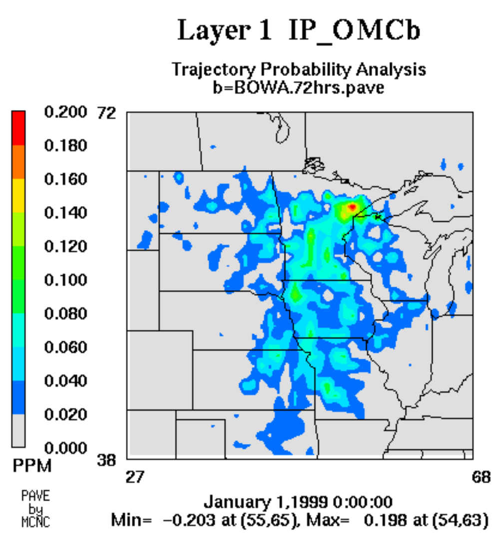
20% Highest Nitrate Days



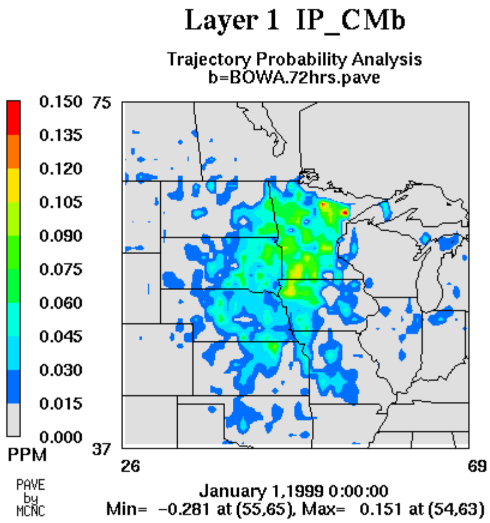
20% Highest Elemental Carbon Days



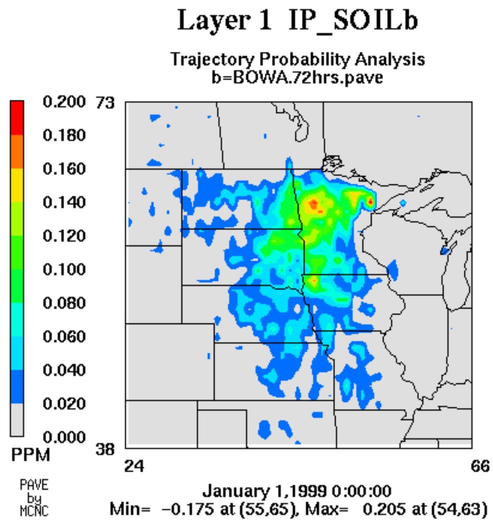
20% Highest Organic Carbon Days



20% Highest Coarse Mass Days



20% Highest Soil Days



Conclusions

The results of this analysis indicate that, for Iowa, priority should be given to more fully understanding the causes of regional haze in Class I areas to the north and northeast of the State of Iowa rather than sites to the west and south. Additionally, the results indicate that all of the reconstructed species responsible for visibility impairment under the federal regional haze regulations, and their relative contribution to that visibility impairment, will need to be investigated.

Finally, more refined analyses are needed to refine estimates of pollutant transport and source region culpability in order to accurately meet the requirements of the regional haze regulations.